Results by Chemical Group

Metals

Lead

CAS No. 7439-92-1

General Information

Elemental lead is a malleable, dense, blue-gray metal. It can be combined to form inorganic and organic molecules. Lead is a naturally occurring element found in soils and rocks. It has a variety of uses in manufacturing ammunition, solders, metal alloys, ceramic glazes, antique-molded or casted ornaments, storage batteries, and shielding from radiation sources. In the past, lead was added to paints and gasoline, and it has been used in plumbing for centuries. Small amounts of lead also may be produced from the burning of fossil fuels.

Since the elimination of leaded gasoline in the United States, general lead exposures for adults have resulted from occupational and recreational sources. For children, the major sources of exposure are from deteriorated

Table 2. Lead

Geometric mean and selected percentiles of blood concentrations (in µg/dL) for the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 1 and older	1.66 (1.58-1.73)	.800 (.700-.800)	1.00 (1.00-1.10)	1.60 (1.50-1.60)	2.40 (2.30-2.60)	3.80 (3.50-4.00)	4.90 (4.50-5.50)	7970
Age group								
1-5 years	2.23 (1.99-2.49)	1.00 (.800-1.10)	1.40 (1.10-1.50)	2.20 (1.90-2.50)	3.30 (2.80-3.90)	4.80 (4.00-6.60)	7.00 (5.20-9.90)	723
6-11 years	1.51 (1.35-1.69)	.700 (.600-.900)	.900 (.800-1.10)	1.30 (1.20-1.60)	2.00 (1.70-2.40)	3.30 (2.60-3.90)	4.50 (3.30-6.30)	905
12-19 years	1.10 (1.03-1.18)	.400 (.400-.500)	.800 (.700-.800)	1.00 (1.00-1.10)	1.40 (1.30-1.60)	2.30 (2.10-2.40)	2.80 (2.50-3.00)	2135
20 years and older	1.75 (1.67-1.83)	.700 (.700-.800)	1.00 (1.00-1.10)	1.70 (1.60-1.70)	2.50 (2.40-2.70)	3.90 (3.60-4.10)	5.20 (4.70-5.70)	4207
Gender								
Males	2.01 (1.92-2.10)	.800 (.800-.900)	1.30 (1.20-1.30)	1.80 (1.80-1.90)	2.90 (2.70-3.00)	4.40 (4.00-4.80)	6.00 (5.40-6.50)	3913
Females	1.37 (1.30-1.45)	.600 (.500-.600)	.800 (.800-.900)	1.30 (1.20-1.30)	1.90 (1.80-2.10)	3.00 (2.80-3.30)	4.00 (3.60-4.40)	4057
Race/ethnicity								
Mexican Americans	1.83 (1.71-1.95)	.800 (.700-.800)	1.20 (1.10-1.20)	1.80 (1.60-1.90)	2.70 (2.50-3.00)	4.20 (3.80-4.60)	5.80 (5.10-6.60)	2743
Non-Hispanic blacks	1.87 (1.73-2.02)	.700 (.700-.800)	1.10 (1.00-1.30)	1.70 (1.60-1.90)	2.80 (2.50-2.90)	4.20 (3.90-4.70)	5.70 (5.00-6.30)	1842
Non-Hispanic whites	1.62 (1.53-1.71)	.600 (.600-.700)	1.00 (1.00-1.10)	1.60 (1.40-1.60)	2.40 (2.20-2.50)	3.60 (3.30-3.90)	5.00 (4.30-5.90)	2715

lead-based paint and the resulting dust and soil contamination. Other sources of exposure, such as the use of lead solder in canned foods and in leaded water pipes, have also been eliminated. However, uncommon sources of exposure still exist, including unglazed low-temperature-fired ceramic pottery, pewter drinking vessels, plumbing systems with lead-soldered joints, old paint removal, indoor firing ranges, and nearby mining and smelting operations.

Increasing amounts of lead in the body, as benchmarked by blood lead levels (BLLs), can cause impaired neurobehavioral development in children, increased blood pressure, kidney injury, and anemia (CDC, 2002). Neurophysiologic decrements can occur in adults as a result of workplace exposure to lead (Araki et al., 2000). At extremely high levels, lead will produce severe central nervous system injury and paralysis. The potential adverse effects of lead on reproduction are areas of ongoing research and may include miscarriage in women with high BLLs and problems with sperm formation in men with high BLLs (Borja-Aburto et al., 1999). The International Agency for Research on Cancer (IARC) has determined on the basis of animal studies that lead is a probable human carcinogen, but more study is needed on the relation of lead exposure to cancer in people (Jemal et al., 2002). Information about external exposure (environmental levels) and health effects is

Table 3. Lead

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.758 (.711-.808)	.200 (.100-.200)	.500 (.400-.500)	.800 (.700-.800)	1.30 (1.30-1.40)	2.10 (1.90-2.30)	2.90 (2.50-3.20)	2465
Age group								
6-11 years	1.07 (.952-1.20)	.500 (.400-.600)	.700 (.500-.800)	1.00 (.900-1.20)	1.50 (1.30-1.70)	2.40 (1.80-3.00)	3.40 (2.40-5.10)	340
12-19 years	.656 (.585-.735)	.100 (.100-.200)	.300 (.300-.400)	.600 (.600-.700)	1.10 (.900-1.20)	1.70 (1.40-2.00)	2.20 (1.90-2.50)	719
20 years and older	.743 (.689-.801)	.200 (.100-.200)	.400 (.300-.400)	.700 (.700-.800)	1.40 (1.20-1.50)	2.10 (1.90-2.30)	2.90 (2.50-3.20)	1406
Gender								
Males	.920 (.848-.998)	.200 (.200-.300)	.500 (.500-.600)	.900 (.800-.900)	1.60 (1.40-1.70)	2.40 (2.20-2.90)	3.40 (2.90-3.90)	1227
Females	.632 (.577-.692)	.200 (<LOD-.200)	.300 (.300-.400)	.600 (.600-.700)	1.20 (1.10-1.30)	1.90 (1.60-2.10)	2.40 (2.10-2.80)	1238
Race/ethnicity								
Mexican Americans	1.02 (.916-1.13)	.200 (.200-.300)	.600 (.400-.600)	1.00 (.900-1.20)	1.70 (1.50-2.00)	2.80 (2.30-3.40)	4.10 (3.10-6.20)	884
Non-Hispanic blacks	1.11 (.983-1.25)	.300 (.300-.400)	.700 (.600-.800)	1.10 (1.00-1.20)	1.90 (1.50-2.10)	2.90 (2.40-3.50)	4.20 (3.20-5.70)	568
Non-Hispanic whites	.686 (.632-.745)	.100 (<LOD-.200)	.300 (.300-.400)	.700 (.600-.700)	1.30 (1.10-1.40)	1.90 (1.70-2.20)	2.60 (2.30-3.10)	822

< LOD means less than the limit of detection, which is 0.07 µg/L.

available from the EPA IRIS Web site at http://www.epa.gov/iris and from ATSDR at http://www.atsdr.cdc.gov/toxprofiles.

Interpreting Blood and Urine Lead Levels Reported in the Tables

In this NHANES 1999-2000 sample, BLLs were measured in all participants aged 1 year and older, and urine lead levels were measured in a sample of people aged 6 years and older. Blood lead measurement is the preferred method of evaluating lead exposure and its health effects in people. BLLs are contributed to by both recent intake and an equilibration with stored lead in other tissues. Urinary lead measurements tend to reflect mostly recent exposure and are therefore more variable than blood lead levels for a given individual. Urinary levels of lead above 20 µg/L should be evaluated by blood lead analysis, if such analyses have not already been conducted.

The U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), requires monitoring of blood lead and reduction of exposure to lead when worker BLLs are higher than 40 µg/dL of whole blood [CFR 1910.1025(j)(2)(i)]. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that BLLs in workers not exceed 30 µg/dL. The

Table 4. Lead (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.714 (.671-.759)	.294 (.259-.313)	.444 (.412-.476)	.699 (.655-.745)	1.11 (1.03-1.19)	1.70 (1.55-1.91)	2.37 (2.15-2.86)	2465
Age group								
6-11 years	1.17 (.967-1.42)	.533 (.450-.625)	.746 (.639-.870)	1.06 (.899-1.22)	1.55 (1.25-1.90)	2.71 (1.63-4.71)	4.66 (2.03-18.0)	340
12-19 years	.494 (.457-.535)	.216 (.190-.267)	.328 (.296-.354)	.469 (.415-.494)	.702 (.632-.833)	1.10 (.968-1.33)	1.65 (1.21-2.78)	719
20 years and older	.711 (.665-.760)	.294 (.256-.333)	.452 (.419-.489)	.709 (.652-.750)	1.10 (1.02-1.19)	1.69 (1.50-1.91)	2.31 (2.00-2.74)	1406
Gender								
Males	.718 (.669-.771)	.302 (.258-.343)	.446 (.408-.489)	.693 (.639-.745)	1.10 (.997-1.22)	1.68 (1.50-2.00)	2.43 (2.04-3.33)	1227
Females	.710 (.658-.767)	.290 (.246-.320)	.442 (.392-.481)	.701 (.655-.762)	1.11 (1.04-1.20)	1.74 (1.50-2.02)	2.38 (2.02-2.88)	1238
Race/ethnicity								
Mexican Americans	.939 (.868-1.02)	.367 (.333-.446)	.593 (.516-.667)	.882 (.800-1.02)	1.43 (1.33-1.58)	2.38 (2.05-2.83)	3.31 (2.78-4.18)	884
Non-Hispanic blacks	.720 (.643-.807)	.290 (.258-.351)	.455 (.392-.491)	.667 (.579-.757)	1.11 (.973-1.20)	1.98 (1.52-2.52)	2.83 (2.25-3.70)	568
Non-Hispanic whites	.687 (.630-.749)	.289 (.245-.317)	.423 (.387-.461)	.673 (.619-.732)	1.07 (.987-1.15)	1.66 (1.48-1.86)	2.31 (1.89-2.88)	822

Deutsche Forschungsgemeinschaft provides a Biological Tolerance Level (BAT) of 40 µg/dL for workers. The World Health Organization (WHO) level of concern is 20 µg/dL. CDC recommends that children's levels not exceed 10 µg/dL.

Data from NHANES III, phase 2 (1991-1994) showed that 4.4% of children aged 1-5 years had BLLs greater than or equal to 10 µg/dL, and the geometric mean BLL for children 1-5 years old was 2.7 µg/dL (Pirkle et al., 1998). For the current NHANES 1999-2000 sample, 2.2% of children aged 1-5 years had BLLs greater than or equal to 10 µg/dL, with a geometric mean BLL of 2.23 µg/dL. Higher prevalences of elevated BLLs in U.S. children occur in urban settings, lower socioeconomic groups, immigrants, and refugees (Geltman et al., 2001). Children with BLLs greater than or equal to 10 µg/dL are at increased risk for neurocognitive decrements. Pronounced health effects from lead exposure, namely anemia, kidney injury, nerve injury, and overt brain dysfunction, occur at higher levels. In places where leaded gasoline is still used, such as Bangladesh, BLLs are similar to those in the United States before the removal of lead from gasoline (e.g., a mean BLL of 15.0 µg/dL and 87.4% with levels in excess of 10 µg/dL [Kaiser et al., 2001]).

Geometric mean BLLs of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, and log serum cotinine. Adjusted geometric mean BLLs were higher in children aged 1-5 years than in children aged 6-11 years, and both these age groups had higher levels than did those aged 12-19 years. BLLs in adults aged 20 years and older were higher than those in the group aged 12-19 years but lower than in children aged 1-5 years. BLLs for males were higher than those for females. Mexican Americans and non-Hispanic blacks had higher levels than did non-Hispanic whites. Similar demographic differences were observed for urine lead levels. It is unknown whether differences between ages or races/ethnicities represent differences in exposure, body-size relationships, or metabolism. For instance, to account for the decreasing BLLs observed with increasing childhood ages, several explanations are possible, including decreasing exposure, dilution of lead by growth of body mass, or changing equilibria with bone turnover. Among adults, BLLs increase slowly with age.

Cadmium

CAS No. 7440-43-9

General Information

Elemental cadmium is a silver-white metal. In nature, it usually is found combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide). Cadmium does not corrode easily and has many uses. In industry and consumer products, it is used in batteries, pigments, metal coatings, and plastics. Cadmium enters the environment from the weathering and mining of rocks and minerals that contain cadmium. Contaminated water sources, foods, and combustion sources may also result in human exposure. Cadmium exposure occurs from inhalation of cigarette smoke. Cadmium can be absorbed by inhalation or ingestion. Exposure to cadmium may occur in industries, such as mining or electroplating, which use or produce the chemical.

Cadmium and its compounds are toxic. Once absorbed into the body, cadmium may remain for decades. Low-level chronic exposures over many years may result in

Table 5. Cadmium

Geometric mean and selected percentiles of blood concentrations (in µg/L) for the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 1 and older	.412 (.386-.439)	< LOD	< LOD	.300 (.300-.400)	.600 (.500-.600)	1.00 (.900-1.00)	1.30 (1.20-1.40)	7970
Age group								
1-5 years	*	< LOD	< LOD	< LOD	.300 (<LOD-.300)	.400 (.300-.400)	.400 (.300-.400)	723
6-11 years	*	< LOD	< LOD	< LOD	.300 (<LOD-.300)	.400 (.300-.400)	.400 (.400-.500)	905
12-19 years	.333 (.309-.360)	< LOD	< LOD	.300 (<LOD-.300)	.300 (.300-.400)	.800 (.600-.900)	1.10 (.900-1.10)	2135
20 years and older	.468 (.436-.502)	< LOD	< LOD	.400 (.300-.400)	.600 (.600-.700)	1.00 (1.00-1.10)	1.50 (1.40-1.60)	4207
Gender								
Males	.403 (.376-.431)	< LOD	< LOD	.400 (.300-.400)	.600 (.500-.600)	1.00 (.900-1.00)	1.30 (1.20-1.50)	3913
Females	.421 (.394-.451)	< LOD	< LOD	.300 (.300-.400)	.600 (.500-.600)	1.00 (.800-1.00)	1.30 (1.10-1.40)	4057
Race/ethnicity								
Mexican Americans	.395 (.368-.423)	< LOD	< LOD	.400 (.300-.400)	.400 (.400-.500)	.700 (.700-.900)	1.10 (.900-1.30)	2743
Non-Hispanic blacks	.393 (.367-.421)	< LOD	< LOD	.300 (.300-.400)	.600 (.500-.600)	1.00 (.800-1.00)	1.40 (1.20-1.50)	1842
Non-Hispanic whites	.420 (.388-.456)	< LOD	< LOD	.400 (.300-.400)	.500 (.500-.600)	1.00 (.900-1.10)	1.30 (1.20-1.40)	2715

< LOD means less than the limit of detection, which is 0.3 µg/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

accumulation of cadmium in the kidneys. When the amount of cadmium exceeds the ability of the kidney cells to produce a binding protein that keeps the cadmium biologically inactive, serious kidney damage may occur. Chronic ingestion also has produced painful osteomalacia, a bone disorder similar to rickets in children. Large, acute airborne exposures to dusts and fumes, as occurs for example from welding on cadmium-alloyed metals, may result in severe swelling of the lungs (edema) and subsequent scarring (fibrosis). Other cadmium toxicity, as seen in animal studies, includes reproductive and teratogenic effects. IARC has determined that cadmium is a known human carcinogen. Information about external exposure (environmental levels) and health effects is available from the EPA IRIS Web site at http://www.epa.gov/iris and from ATSDR at http://www.atsdr.cdc.gov/toxprofiles.

Interpreting Blood and Urine Cadmium Levels Reported in the Tables

In the NHANES 1999-2000 sample, blood cadmium levels were measured in all participants aged 1 year and older, and urine cadmium levels were measured in a sample of people aged 6 years and older. Finding a measurable amount of cadmium in the blood or urine does not mean that the level of cadmium causes an adverse health effect. OSHA (1998) has developed criteria for evaluating occupational exposures. These occupational criteria are to be used to assess chronic

Table 6. Cadmium

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.326 (.306-.347)	.110 (.090-.110)	.190 (.170-.200)	.330 (.310-.350)	.590 (.550-.640)	1.01 (.910-1.11)	1.36 (1.21-1.53)	2465
Age group								
6-11 years	.211 (.180-.248)	.080 (<LOD-.110)	.120 (.100-.160)	.210 (.170-.260)	.340 (.290-.380)	.460 (.380-.900)	.760 (.400-1.61)	340
12-19 years	.218 (.197-.242)	.070 (<LOD-.100)	.140 (.120-.160)	.240 (.210-.270)	.360 (.330-.420)	.510 (.440-.550)	.630 (.520-.780)	719
20 years and older	.368 (.344-.394)	.110 (.110-.130)	.200 (.180-.220)	.390 (.360-.420)	.670 (.620-.740)	1.11 (1.00-1.25)	1.51 (1.33-1.69)	1406
Gender								
Males	.347 (.316-.381)	.110 (.100-.130)	.190 (.170-.220)	.360 (.320-.380)	.620 (.540-.710)	1.03 (.920-1.30)	1.61 (1.21-1.89)	1227
Females	.307 (.282-.334)	.080 (.060-.110)	.170 (.140-.190)	.340 (.300-.350)	.590 (.540-.630)	.960 (.840-1.05)	1.25 (1.13-1.37)	1238
Race/ethnicity								
Mexican Americans	.310 (.280-.344)	.110 (.090-.130)	.170 (.150-.200)	.290 (.270-.320)	.600 (.500-.670)	.950 (.820-1.06)	1.24 (1.06-1.45)	884
Non-Hispanic blacks	.441 (.386-.504)	.160 (.130-.170)	.250 (.200-.300)	.440 (.390-.530)	.750 (.670-.890)	1.36 (1.13-1.48)	1.72 (1.44-2.00)	568
Non-Hispanic whites	.311 (.285-.338)	.100 (.080-.110)	.160 (.140-.190)	.330 (.300-.350)	.560 (.510-.620)	.980 (.830-1.12)	1.33 (1.13-1.61)	822

< LOD means less than the limit of detection, which is 0.04 µg/L.

workplace exposure. For blood cadmium, the criterion is 5 µg/L of blood; for urine cadmium, the criterion is 3 µg/gram of creatinine. Occupational criteria are provided here for comparison only, not to imply a safety level for general population exposure. The 95th percentile for blood cadmium reported in Table 5 is less than the OSHA criterion for blood cadmium, and the 95th percentile for urine cadmium shown in Table 7 is less than the OSHA criterion for urine cadmium.

In a previous study of a non-random subsample from NHANES III (Paschal et al., 2000), levels of cadmium were similar to levels in this NHANES 1999-2000 sample. In this *Report*, geometric mean levels of blood cadmium for the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, log serum cotinine, and urinary creatinine. Females had slightly higher levels than males. Mexican Americans had higher blood cadmium levels than non-Hispanic whites or non-Hispanic blacks. Similar relationships for age, gender, and smoking were found in the study of NHANES III participants (Paschal et al., 2000). It is unknown whether differences between ages, genders, or races/ethnicities represent differences in exposure, body-size relationships, or metabolism.

Blood cadmium reflects recent and cumulative exposures, whereas urinary cadmium reflects losses from the kidney as protein binding is exceeded (Lauwerys and Hoet, 2001; Satarug et al. 2002). In occupational studies

Table 7. Cadmium (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.307 (.290-.324)	.122 (.115-.134)	.188 (.174-.200)	.296 (.274-.315)	.496 (.466-.527)	.797 (.743-.850)	1.03 (.916-1.14)	2465
Age group								
6-11 years	.232 (.202-.265)	.120 (.113-.145)	.170 (.145-.191)	.221 (.200-.242)	.299 (.268-.342)	.414 (.321-.700)	.569 (.342-1.99)	340
12-19 years	.164 (.151-.179)	.088 (.070-.106)	.121 (.113-.130)	.160 (.152-.173)	.230 (.198-.258)	.315 (.267-.364)	.376 (.321-.500)	719
20 years and older	.353 (.333-.373)	.145 (.122-.163)	.220 (.200-.240)	.351 (.332-.375)	.581 (.534-.617)	.852 (.798-.947)	1.13 (.977-1.24)	1406
Gender								
Males	.271 (.252-.291)	.112 (.101-.128)	.164 (.153-.183)	.255 (.240-.271)	.421 (.385-.457)	.720 (.636-.785)	.890 (.794-1.13)	1227
Females	.345 (.322-.370)	.143 (.121-.161)	.213 (.195-.232)	.344 (.319-.364)	.566 (.509-.614)	.857 (.786-.953)	1.13 (.966-1.31)	1238
Race/ethnicity								
Mexican Americans	.286 (.264-.311)	.135 (.120-.145)	.176 (.161-.188)	.265 (.246-.289)	.432 (.377-.483)	.759 (.588-.899)	.968 (.787-1.13)	884
Non-Hispanic blacks	.287 (.256-.321)	.115 (.096-.142)	.171 (.161-.186)	.274 (.249-.313)	.500 (.420-.556)	.740 (.659-.841)	.929 (.782-1.06)	568
Non-Hispanic whites	.311 (.288-.336)	.120 (.108-.140)	.187 (.170-.205)	.302 (.271-.333)	.509 (.457-.570)	.817 (.751-.912)	1.12 (.916-1.33)	822

of exposed males, urinary cadmium thresholds corresponding to significant increased excretion of renal protein markers have ranged from 2.4 µg/gram to 11.5 µg/gram of creatinine. A threshold of 10 µg/gram of creatinine has been suggested for the occurrence of reversible low-molecular mass proteinuria (functional effect) and subsequent loss of renal filtration reserve capacity (Roels et al., 1999). This threshold also approximates the critical cadmium concentration in the renal cortex of 200 µg of cadmium per gram of tissue. In this *Report*, geometric mean levels of urinary cadmium for the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, log serum cotinine, and urinary creatinine. There were no differences in the adjusted geometric means of urine cadmium for the race/ethnicity categories. People aged 12-19 years had lower urinary cadmium levels than either children aged 6-11 years or adults aged 20 years and older. Urinary cadmium levels in males were lower than in females. It is unknown whether differences between ages or genders represent differences in exposure, body-size relationships, or metabolism.

Whether cadmium at the levels reported here is a cause for health concern is not yet known; more research is needed. Measuring cadmium at these levels in blood and urine is possible because of advances in analytical chemistry. These data provide physicians with a reference range so they can determine whether people have been exposed to higher levels of cadmium than those found in the general population. These data also will help scientists plan and conduct research about cadmium exposure and health effects.

Mercury

CAS No. 7439-97-6

General Information

Mercury is a naturally occurring metal that has metallic, inorganic, and organic forms. Metallic mercury (quicksilver) is a shiny, silver-white liquid. Metallic elemental mercury is used to produce chlorine gas and caustic soda. It also can be used in detonating devices, cosmetics, pharmaceuticals, pesticides, blood pressure devices, electrical equipment (e.g., thermostats and switches), thermometers, dental fillings, and batteries. Spills of metallic mercury can volatilize into the air and be inhaled. Elemental mercury is poorly absorbed from the gastrointestinal tract. Vaporization of mercury from dental amalgams also contributes to exposure (Ritchie et al., 2002).

Inorganic mercury exists in two oxidative states (mercurous and mercuric) and combines with other elements, such as chlorine (e.g., mercuric chloride), sulfur, or oxygen, to form inorganic mercury compounds or salts. Inorganic mercury enters the air from the mining of ore deposits, the burning of coal, and the incineration of waste. It also enters the water or soil from natural deposits, disposal of wastes, and volcanic activity.

Mercury can combine with organic compounds (e.g., methyl mercury, phenyl mercury, merthiolate). In mercury-contaminated water or soil, microorganisms can organify mercury into methyl mercury, which concentrates in the food chain. Fish consumption is the primary source of methyl mercury exposure in people.

The health effects of mercury are diverse and can depend on the form of the mercury encountered and the severity and length of exposure. With large acute exposures to elemental mercury vapor, the lungs may be injured. At levels below those that cause lung injury, low-dose or

Table 8. Mercury

Geometric mean and selected percentiles of blood concentrations (in µg/L) for males and females aged 1 to 5 years and females aged 16 to 49 years in the U.S. population, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Age group								
1-5 years (males and females)	.343 (.299-.393)	< LOD	< LOD	.300 (.200-.300)	.500 (.500-.600)	1.40 (1.10-2.00)	2.30 (1.40-3.20)	705
Males	.317 (.270-.372)	< LOD	< LOD	.200 (.200-.300)	.500 (.500-.600)	1.10 (.800-1.50)	2.10 (1.10-3.50)	387
Females	.377 (.311-.457)	< LOD	< LOD	.200 (.200-.300)	.800 (.500-1.00)	1.60 (1.20-2.30)	2.70 (1.80-4.80)	318
16-49 years (females)	1.02 (.860-1.22)	.200 (<LOD-.200)	.400 (.400-.600)	.900 (.800-1.20)	2.00 (1.60-2.70)	4.90 (4.00-6.10)	7.10 (5.60-9.90)	1709
Race/ethnicity (females,16-49 years)								
Mexican Americans	.820 (.691-.974)	.200 (<LOD-.200)	.400 (.300-.500)	.900 (.700-1.00)	1.40 (1.20-1.90)	2.60 (2.10-3.40)	4.00 (2.70-5.50)	579
Non-Hispanic blacks	1.35 (1.11-1.64)	.300 (.200-.500)	.600 (.500-.900)	1.30 (1.10-1.60)	2.60 (1.90-3.30)	4.80 (3.30-6.60)	5.90 (4.40-10.9)	370
Non-Hispanic whites	.944 (.765-1.17)	< LOD	.400 (.300-.400)	.900 (.700-1.10)	1.90 (1.40-2.90)	5.00 (3.40-6.50)	6.90 (5.40-10.6)	588

< LOD means less than the limit of detection, which is 0.14 µg/L.

chronic inhalation may affect the nervous system. Symptoms include weakness; fatigue; loss of weight (with anorexia); gastrointestinal disturbances; salivation; tremors; and behavioral and personality changes, including depression and emotional instability.

Exposure to inorganic mercury usually occurs by ingestion. The most prominent effect is on the kidneys, where mercury accumulates, leading to tubular necrosis. In addition, there may be an irritant or corrosive effect on the gastrointestinal tract involving stomatitis, ulceration, diarrhea, vomiting, and bleeding. Psychomotor and neuromuscular effects also may occur.

Organic mercury is more toxic than inorganic mercury. The effects of organic mercury include changes in vision, sensory disturbances in the arms and legs, cognitive disturbances, dermatitis, and muscle wasting. The developing nervous systems of the fetus and infants are considered to be susceptible to the effects of methyl mercury as measured by neurobehavioral testing in population studies (National Academy of Sciences, 2000). Information about external exposure (environmental levels) and health effects is available at the EPA IRIS Web site at http://www.epa.gov/iris and from ATSDR at http://www.atsdr.cdc.gov/toxprofiles.

Interpreting Blood and Urine Mercury Levels Reported in the Tables

Blood mercury levels were measured in a subsample of NHANES participants aged 1-5 years and in females aged 16-49 years. Urine mercury levels were measured in a subsample of females aged 16-49 years. Subsamples were randomly selected within the specified age ranges to be a representative sample of the U.S. population. The measurement of total blood mercury includes both inorganic and organic forms. In the general population, total blood mercury is due mostly to the dietary intake of organic forms, particularly methyl mercury. Urinary mercury mostly comprises inorganic mercury, since little organic mercury is excreted in the urine. These distinctions can assist in the interpretation of the meaning of elevated mercury blood levels in people. Finding a measurable amount of mercury in blood or urine does not mean that the level of mercury causes an adverse health effect.

Total blood mercury levels in this *Report* were well below occupational thresholds of concern. ACGIH recommends that the blood inorganic mercury of workers not exceed 15 µg/L and that urine values not exceed 35 µg/gram of creatinine. Information about the biological exposure indices (BEI) is provided here for comparison,

Table 9. Mercury

Geometric mean and selected percentiles of urine concentrations (in µg/L) for females aged 16 to 49 years in the U.S. population, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Age group (females)								
16-49 years	.720 (.642-.808)	< LOD	.310 (.260-.370)	.770 (.650-.880)	1.62 (1.46-1.84)	3.15 (2.68-3.58)	5.00 (3.86-5.55)	1748
Race/ethnicity (females,16-49 years)								
Mexican Americans	.724 (.607-.864)	< LOD	.280 (.240-.350)	.650 (.520-.890)	1.69 (1.33-2.35)	3.68 (3.10-4.45)	5.62 (4.68-7.51)	595
Non-Hispanic blacks	1.07 (.888-1.29)	< LOD	.450 (.360-.650)	1.03 (.870-1.34)	2.30 (1.85-2.89)	4.81 (3.41-6.08)	6.98 (5.13-9.64)	381
Non-Hispanic whites	.657 (.576-.748)	< LOD	.280 (.210-.340)	.710 (.560-.810)	1.50 (1.31-1.77)	2.84 (2.35-3.32)	4.05 (3.26-5.24)	594

< LOD means less than the limit of detection, which is 0.14 µg/L.

not to imply that the BEI is a safety level for general population exposure. The measurement of urinary protein excretion for assessment of early kidney tubular damage is also recommended. Roels et al. (1999) evaluated the utility of urinary mercury concentrations in assessing renal injury. They concluded that, to prevent cytotoxic and functional renal effects, urinary mercury levels should not exceed 50 µg/gram of creatinine.

Blood mercury levels in this NHANES 1999-2000 subsample are consistent with levels found in other population studies. In Germany, the geometric mean for blood mercury was 0.58 µg/L in all 4,645 participants and was 0.33 µg/L for children 6-14 years old (Becker et al., 1998). During the years 1996 through 1998, Benes et al. (2000) studied 1,216 blood donors (896 males and 320 females; average age 33 years) and 758 children (average age 9.9 years). They found median concentrations of mercury in blood for adults (medians) of 0.78 µg/L and in the juvenile population of 0.46 µg/L. Total blood mercury is known to increase with greater fish consumption (Grandjean et al., 1995; Mahaffey and Mergler 1998; Sanzo et al., 2001; Dewailly et al., 2001) and with the number of teeth filled with mercury-containing amalgams (Becker et al., 1998). The levels reported in this NHANES 1999-2000 subsample for maternal-aged females were below levels associated with *in utero* effects on the fetus, or with effects in children and adults (National Academy of Sciences, 2000).

Geometric mean blood mercury levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, log serum cotinine, and urinary creatinine. Females aged 16-49 years had blood mercury levels that were more than double those of children aged 1-5 years. Among children 1-5 years old, girls had higher values than boys. In addition, non-Hispanic whites had lower blood mercury levels than either non-Hispanic blacks or Mexican Americans. Among maternal-aged women (16-49 years old), blood mercury levels in non-Hispanic blacks were higher than levels in non-Hispanic whites and Mexican Americans.

In this *Report*, no differences existed between racial/ethnic groups for urinary mercury levels. Use of certain mercury-containing cosmetic creams can increase urine mercury levels slightly (McRill et al., 2000).

These data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of mercury than those found in the general population. These data will also help scientists plan and conduct research about mercury exposure and health effects.

Table 10. Mercury (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for females aged 16 to 49 years in the U.S. population, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval) 10th	25th	50th	75th	90th	95th	Sample size
Age group (females)								
16-49 years	.711 (.638-.792)	< LOD	.354 (.294-.422)	.723 (.640-.832)	1.41 (1.28-1.59)	2.48 (2.21-2.79)	3.27 (2.94-3.70)	1748
Race/ethnicity (females,16-49 years)								
Mexican Americans	.685 (.555-.846)	< LOD	.312 (.244-.400)	.639 (.487-.836)	1.45 (1.12-1.88)	2.89 (2.01-3.70)	4.51 (3.20-5.48)	595
Non-Hispanic blacks	.666 (.558-.796)	< LOD	.335 (.266-.414)	.615 (.503-.837)	1.22 (1.01-1.63)	2.56 (1.90-3.65)	3.99 (2.90-4.70)	381
Non-Hispanic whites	.706 (.621-.803)	< LOD	.368 (.289-.455)	.721 (.632-.846)	1.41 (1.26-1.64)	2.46 (2.16-2.78)	3.05 (2.56-3.76)	594

< LOD means less than the limit of detection (see previous table).

Cobalt

CAS No. 7440-48-4

General Information

Cobalt is a magnetic element that occurs in nature either as a steel-gray, shiny, hard metal or in combination with other elements. The cobalt used in U.S. industry is imported or obtained by recycling scrap metal that contains cobalt. Among its many uses are in the manufacture of hard-metal alloys (in combination with tungsten carbide), blue-colored pigments, and fertilizers. Cobalt is added to some paints and to porcelain enamel for use on steel bathroom fixtures, large appliances, and kitchenware. Cobalt carbonyls are used as catalysts in the synthesis of polyester and other materials. Small amounts of cobalt naturally occur in food; vitamin B_{12} is a cobalt-containing compound that is essential to good health.

Cobalt occurs naturally in dust, seawater, and many types of soil. It is also emitted into the environment from burning coal and oil and from car and truck exhaust. Usual human exposure is from food sources. Exposure in the workplace may come from electroplating, the processing of alloys, or the grinding of tungsten carbide-type metal-cutting tools. Workplace standards for external air exposure to cobalt and several of its compounds have been established (OSHA, ACGIH). Pneumoconiosis, asthma, contact dermatitis, and cardiomyopathy have occurred following chronic, high-level

Table 11. Cobalt

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.372 (.347-.399)	.130 (.110-.140)	.220 (.200-.250)	.400 (.370-.420)	.630 (.580-.660)	.940 (.880-1.06)	1.32 (1.16-1.45)	2465
Age group								
6-11 years	.498 (.438-.565)	.220 (.150-.320)	.350 (.280-.430)	.520 (.450-.580)	.740 (.640-.850)	1.03 (.860-1.12)	1.22 (1.03-1.50)	340
12-19 years	.517 (.466-.574)	.200 (.170-.250)	.350 (.290-.390)	.520 (.490-.540)	.810 (.670-.870)	1.16 (1.01-1.47)	1.52 (1.24-2.57)	719
20 years and older	.339 (.313-.368)	.120 (.100-.130)	.200 (.180-.230)	.360 (.330-.400)	.560 (.520-.630)	.880 (.790-.970)	1.28 (1.06-1.45)	1406
Gender								
Males	.369 (.342-.398)	.150 (.120-.170)	.230 (.210-.280)	.400 (.380-.420)	.580 (.540-.630)	.810 (.750-.880)	1.01 (.910-1.12)	1227
Females	.375 (.340-.415)	.120 (.100-.140)	.220 (.180-.240)	.410 (.350-.440)	.670 (.600-.750)	1.17 (.970-1.34)	1.49 (1.28-1.98)	1238
Race/ethnicity								
Mexican Americans	.415 (.370-.466)	.130 (.100-.180)	.250 (.220-.310)	.470 (.400-.510)	.660 (.630-.740)	1.05 (.930-1.22)	1.47 (1.25-1.61)	884
Non-Hispanic blacks	.433 (.401-.467)	.160 (.140-.190)	.270 (.240-.290)	.420 (.390-.470)	.680 (.610-.780)	1.15 (1.02-1.25)	1.45 (1.22-2.04)	568
Non-Hispanic whites	.365 (.332-.402)	.120 (.090-.130)	.220 (.190-.260)	.400 (.350-.430)	.620 (.560-.670)	.930 (.840-1.06)	1.29 (1.06-1.49)	822

exposures in the workplace or as a result of chronic unintentional exposures. A mild reduction in thyroid function was noted in one worker study (Swennen et al., 1993). Cobalt is considered an animal carcinogen, but evidence of its carcinogenicity in people is inadequate (IARC). Information about external exposure (environmental levels) and health effects is available from ATSDR at http://www.atsdr.cdc.gov/toxprofiles.

Interpreting Urine Cobalt Levels Reported in the Tables

Urine cobalt levels were measured in a subsample of NHANES participants aged 6 years and older. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. Measuring cobalt at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of cobalt in urine does not mean that the level of cobalt causes an adverse health effect.

For workers exposed to cobalt in the air, the distinction between soluble cobalt and insoluble (oxides and metallic) cobalt should be made (Christensen and Poulsen, 1994; Lison et al., 1994). Exposure to soluble cobalt salts will produce proportionately higher urinary levels because of better absorption. The ACGIH BEI is 15 µg/L at a threshold limit value (as a time-weighted average) of air exposure at 20 µg/m^3 and applies only to exposures from soluble forms of cobalt. Correlations between air-exposure levels and urinary cobalt levels in

Table 12. Cobalt (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval) 10th	25th	50th	75th	90th	95th	Sample size
Total, age 6 and older	.350 (.328-.374)	.162 (.147-.175)	.224 (.210-.236)	.326 (.307-.355)	.507 (.471-.561)	.821 (.723-.913)	1.16 (.955-1.41)	2465
Age group								
6-11 years	.546 (.487-.611)	.287 (.256-.322)	.391 (.338-.436)	.548 (.471-.625)	.774 (.629-.938)	1.00 (.833-1.48)	1.23 (.895-1.50)	340
12-19 years	.390 (.353-.430)	.176 (.165-.189)	.259 (.227-.284)	.374 (.330-.397)	.535 (.469-.586)	.824 (.640-1.10)	1.44 (.805-3.54)	719
20 years and older	.325 (.302-.350)	.152 (.138-.170)	.211 (.193-.226)	.302 (.278-.324)	.465 (.431-.500)	.727 (.667-.861)	1.12 (.913-1.30)	1406
Gender								
Males	.288 (.268-.309)	.139 (.120-.156)	.191 (.176-.214)	.277 (.256-.294)	.400 (.375-.436)	.608 (.545-.706)	.833 (.679-1.05)	1227
Females	.422 (.389-.457)	.190 (.180-.211)	.262 (.238-.289)	.405 (.366-.443)	.605 (.561-.667)	.955 (.861-1.16)	1.50 (1.14-1.64)	1238
Race/ethnicity								
Mexican Americans	.383 (.346-.424)	.163 (.134-.205)	.246 (.212-.280)	.376 (.342-.409)	.598 (.510-.656)	.898 (.786-1.01)	1.23 (1.11-1.35)	884
Non-Hispanic blacks	.281 (.265-.299)	.122 (.113-.139)	.174 (.163-.201)	.254 (.238-.280)	.417 (.375-.467)	.707 (.604-.774)	.975 (.757-1.45)	568
Non-Hispanic whites	.366 (.335-.399)	.172 (.150-.187)	.234 (.211-.256)	.344 (.314-.378)	.520 (.468-.586)	.861 (.721-.972)	1.25 (.957-1.50)	822

hard-metal fabricators are well documented (Ichikawa et al., 1985; Linnainmaa and Kiilunen, 1997; ACGIH 2001; Kraus et al., 2001; Lauwerys and Hoet, 2001). Air and urine cobalt levels for the workplace have been set as parallel standards in Germany. For instance, a urinary level of 30 µg/L can result from exposure to 0.05 mg/m^3 in the air. Generally, workers have urinary concentrations several to many times higher than general populations. Swennen et al. (1993) reported a median value of 44 µg/gram of creatinine and a maximum value of 2,245 µg/gram of creatinine in cobalt workers. The 95th percentiles of urinary cobalt levels reported for this NHANES 1999-2000 subsample are much less than levels observed during occupational exposures or established occupational levels of concern.

Previous studies reporting urinary levels for general populations in other developed countries have found values roughly similar to those reported in Tables 11 and 12 (White et al., 1998; Minoia, 1990; Lauwerys and Hoet 2001). In addition, levels measured in clinically submitted specimens are also broadly similar (Komaromy-Hiller et al., 2000) to levels documented in this *Report*. A previous study of urinary metals in a non-random subsample from NHANES III participants found several-fold higher values of cobalt, which are likely due to methodologic differences (Paschal et al., 1998). Because concentrations of cobalt in the urine decline rapidly within 24 hours after an exposure ceases (Alexandersson et al., 1988), such measurements reflect recent exposure. Taking multivitamins, tobacco smoking, and the presence of metal joint prostheses may increase cobalt excretion in the urine.

Geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, and urinary creatinine. Urinary cobalt levels were slightly higher for ages 6-11 years than for ages 12-19 years, with both age groups having higher levels than people in the 20 years and older age group. Urinary cobalt levels in females were higher than in males, and levels in non-Hispanic blacks were lower than in either Mexican Americans or non-Hispanic whites. It is unknown whether differences between ages, genders, or races/ethnicities represent differences in exposure, body-size relationships, or metabolism.

Whether cobalt at the levels reported here is a cause for health concern is not yet known; more research is needed. These data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of cobalt than those found in the general population. These data will also help scientists plan and conduct research about cobalt exposure and health effects.

Uranium

CAS No. 7440-61-1

General Information

Uranium is a silver-white, extremely dense, and weakly radioactive metal. It usually occurs as an inorganic compound with oxygen, chlorine, or fluorine. Uranium has many commercial uses, including its use in nuclear weapons, nuclear fuel, armor-piercing shells, in some ceramics, and as an aid in electron microscopy.

Human exposure to uranium occurs primarily in the workplace by inhaling dust and other small particles. Exposure to insoluble uranium oxides and uranium metal via inhalation results in retention of these forms of uranium in the lungs and other tissues with little excreted in the urine. Soluble forms of uranium salts are poorly absorbed in the gastrointestinal tract, but these small amounts can be reflected in urinary measurements. Some uranium can be absorbed from food and water, especially in areas where large amounts of uranium occur naturally.

Workplace air standards for external exposure to soluble and insoluble uranium compounds have been established (OSHA, ACGIH). Although older evaluations suggested the carcinogenicity of uranium among smokers, the U.S. EPA has withdrawn its classification; IARC and the National Toxicology Program (NTP) have no ratings,

Table 13. Uranium

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.007 (.006-.008)	< LOD	< LOD	.007 (.006-.007)	.013 (.011-.015)	.026 (.022-.036)	.046 (.036-.054)	2464
Age group								
6-11 years	.008 (.006-.010)	< LOD	< LOD	.007 (.005-.007)	.013 (.009-.019)	.032 (.019-.046)	.046 (.032-.066)	340
12-19 years	.009 (.007-.010)	< LOD	< LOD	.009 (.008-.009)	.014 (.012-.017)	.025 (.021-.036)	.043 (.029-.066)	719
20 years and older	.007 (.006-.008)	< LOD	< LOD	.007 (.006-.007)	.012 (.010-.015)	.026 (.021-.036)	.045 (.035-.054)	1405
Gender								
Males	.008 (.007-.010)	< LOD	< LOD	.007 (.007-.009)	.015 (.012-.019)	.036 (.024-.044)	.053 (.043-.065)	1227
Females	.006 (.005-.007)	< LOD	< LOD	.006 (.005-.007)	.011 (.009-.013)	.023 (.017-.028)	.035 (.027-.049)	1237
Race/ethnicity								
Mexican Americans	.016 (.012-.022)	< LOD	< LOD	.015 (.011-.021)	.032 (.021-.049)	.059 (.040-.127)	.113 (.054-.298)	883
Non-Hispanic blacks	.008 (.007-.010)	< LOD	< LOD	.007 (.007-.010)	.013 (.011-.018)	.028 (.019-.040)	.049 (.031-.066)	568
Non-Hispanic whites	.007 (.006-.008)	< LOD	< LOD	.007 (.006-.007)	.012 (.009-.013)	.023 (.017-.030)	.041 (.028-.050)	822

< LOD means less than the limit of detection, which is 0.003 µg/L.

and CDC's National Institute for Occupational Safety and Health (NIOSH) classifies uranium as carcinogenic. Information about external exposure and health effects is available from the EPA IRIS Web site at http://www.epa.gov/iris and from ATSDR at http://www.atsdr.cdc.gov/toxprofiles.

Interpreting Urine Uranium Levels Reported in the Tables

Urine uranium levels were measured in a subsample of NHANES participants aged 6 years old and older. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. The analytical method measures only levels of the ^{238}U isotope and not levels of the ^{235}U isotope (higher in enriched uranium used as nuclear fuel). More than 99% of naturally occurring uranium is ^{238}U. Measuring uranium at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of uranium in urine does not mean that the level of uranium causes an adverse health effect.

Uranium may produce renal injury through its chemical effect. The U.S. Nuclear Regulatory Commission (NRC) has set an action level of 15 µg/L for uranium in urine to protect people who are occupationally exposed to uranium (NRC, 1978). Six workers in a depleted uranium program had concentrations of 0.110 to 45 µg/L (Ejnik et al., 2000). In people who drank well water with high

Table 14. Uranium (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.007 (.006-.008)	< LOD	< LOD	.006 (.005-.007)	.011 (.010-.014)	.023 (.019-.027)	.034 (.026-.049)	2464
Age group								
6-11 years	.009 (.007-.010)	< LOD	< LOD	.008 (.006-.010)	.015 (.010-.020)	.026 (.020-.035)	.037 (.026-.077)	340
12-19 years	.006 (.005-.008)	< LOD	< LOD	.006 (.005-.007)	.010 (.008-.014)	.019 (.013-.025)	.030 (.021-.061)	719
20 years and older	.007 (.006-.007)	< LOD	< LOD	.006 (.005-.007)	.011 (.010-.014)	.023 (.019-.027)	.034 (.025-.050)	1405
Gender								
Males	.006 (.006-.007)	< LOD	< LOD	.006 (.005-.007)	.011 (.009-.014)	.021 (.017-.026)	.035 (.024-.054)	1227
Females	.007 (.006-.008)	< LOD	< LOD	.007 (.006-.008)	.012 (.010-.014)	.024 (.020-.027)	.034 (.025-.050)	1237
Race/ethnicity								
Mexican Americans	.015 (.011-.020)	< LOD	< LOD	.014 (.011-.019)	.029 (.019-.048)	.058 (.029-.127)	.100 (.044-.270)	883
Non-Hispanic blacks	.005 (.004-.006)	< LOD	< LOD	.005 (.004-.006)	.008 (.006-.011)	.017 (.011-.027)	.028 (.019-.039)	568
Non-Hispanic whites	.007 (.006-.008)	< LOD	< LOD	.006 (.005-.008)	.011 (.009-.013)	.020 (.015-.024)	.028 (.022-.050)	822

< LOD means less than the limit of detection (see previous table for LOD).

natural uranium concentrations, the median urinary concentration was 0.078 µg/L (ranging up to 5.65 µg/L), and a subtle effect of uranium on calcium and phosphate fractional clearance was indicated (within the normal range of these measures) but without effects on other biochemical or traditional markers of renal function (Kurttio et al., 2002). The urine uranium levels in Table 13 for the NHANES 1999-2000 subsample are well below any of the aforementioned levels.

Dang et al. (1993) and Karpas et al. (1996) reported values for small groups of normal individuals in a range similar to those values seen in this NHANES 1999-2000 subsample. In addition, other studies have demonstrated urinary uranium concentrations that are consistent with levels documented in this *Report*, in that the reported levels were below their respective detection limits (Hamilton et al., 1994; Komaromy-Hiller et al., 2000; Byrne et al., 1991). A previous non-random subsample from NHANES III (n = 499) showed concentrations that are essentially similar to those in Table 13 (Ting et al., 1999). In the current NHANES 1999-2000 subsample, geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, and urinary creatinine. Urinary uranium levels tended to be slightly higher for children aged 6-11 years than for people in the other two age groups. Urinary uranium levels in Mexican Americans were more than twice the levels of either non-Hispanic blacks or non-Hispanic whites. It is unknown whether differences between ages or races/ethnicities represent differences in exposure, body-size relationships, or metabolism.

Whether uranium at the levels reported here is cause for health concern is unknown; more research is needed. These urine uranium data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of uranium than those found in the general population. These data will also help scientists plan and conduct research about uranium exposure and health effects.

Antimony

CAS No. 7440-36-0

General Information

Elemental antimony is a silver-white metal. In nature, antimony can be found in ores or other minerals, usually combined with oxygen to form antimony oxide. Antimony is used in metal alloys, storage batteries, solder, sheet and pipe metal, bearings, castings, and pewter. Antimony oxide is used as a fire-retardant in textiles and plastics. It is also used in paints, ceramics, fireworks, enamels, and glass. One organic antimony compound is still used as an antiparasitic medication.

Antimony gets into the environment from natural sources and from industry. People are exposed to antimony primarily from food and to a lesser extent from drinking water and air. Workplace exposures occur as a result of breathing the air near industries such as smelters, coal-fired plants, and refuse incinerators that process or release antimony. Workplace standards for air exposure to antimony have been established (OSHA, ACGIH). Antimony is considered an animal carcinogen, but evidence of its carcinogenicity in people is inadequate (IARC). Information about external exposure (environmental levels) and health effects is available from the EPA IRIS Web site at http://www.epa.gov/iris and from ATSDR at http://www.atsdr.cdc.gov/toxprofiles.

Table 15. Antimony

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.128 (.116-.140)	.050 (<LOD-.060)	.070 (.070-.090)	.130 (.120-.140)	.210 (.200-.230)	.330 (.290-.350)	.420 (.390-.470)	2276
Age group								
6-11 years	.173 (.152-.197)	.090 (.050-.110)	.130 (.110-.150)	.190 (.160-.210)	.260 (.230-.280)	.350 (.290-.440)	.400 (.320-.600)	316
12-19 years	.156 (.140-.174)	.060 (.050-.080)	.100 (.090-.120)	.170 (.150-.180)	.230 (.210-.260)	.340 (.300-.390)	.460 (.360-.510)	663
20 years and older	.119 (.107-.132)	< LOD	.070 (.060-.090)	.110 (.100-.120)	.190 (.180-.220)	.310 (.280-.350)	.420 (.390-.470)	1297
Gender								
Males	.139 (.127-.153)	.040 (<LOD-.060)	.090 (.070-.100)	.140 (.130-.150)	.240 (.220-.250)	.350 (.310-.380)	.470 (.390-.530)	1132
Females	.118 (.105-.133)	.040 (<LOD-.060)	.080 (.060-.090)	.120 (.100-.130)	.190 (.180-.220)	.300 (.260-.340)	.390 (.340-.470)	1144
Race/ethnicity								
Mexican Americans	.127 (.111-.145)	.040 (<LOD-.060)	.080 (.060-.100)	.130 (.120-.150)	.200 (.180-.230)	.300 (.260-.340)	.410 (.340-.500)	787
Non-Hispanic blacks	.173 (.149-.201)	.070 (.050-.080)	.110 (.090-.140)	.180 (.150-.200)	.260 (.220-.290)	.390 (.310-.470)	.490 (.400-.580)	554
Non-Hispanic whites	.124 (.112-.138)	.040 (<LOD-.060)	.080 (.060-.080)	.120 (.120-.140)	.210 (.180-.220)	.320 (.280-.360)	.400 (.360-.500)	768

< LOD means less than the limit of detection, which is 0.03 µg/L.

Interpreting Urine Antimony Levels Reported in the Tables

Urine antimony levels were measured in a subsample of NHANES participants aged 6 years and older. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. Measuring antimony at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of antimony in urine does not mean that the level of antimony causes an adverse health effect. Several investigations of airborne exposures to antimony in workers show urinary levels that are many times higher than those seen in Table 15, even when exposure levels were below workplace air standards (Kentner et al., 1995; Ludersdorf et al., 1987; Bailly et al., 1991). Kentner et al. proposed a urinary limit of 260 µg/gram of creatinine for workplace air exposures equivalent to an air concentration of 500 $\mu g/m^3$ of antimony hydride. Previous studies reporting measurements on normal populations (Minoia et al., 1990; Paschal et al., 1998) or compiled reference ranges (Hamilton et al., 1994) have found values slightly higher than those reported in Table 15, some of which may be due to methodologic differences, although population and exposure differences may exist. The variation of urinary antimony levels across this NHANES 1999-2000 subsample was narrow, possibly indicating limited opportunities for exposure.

Table 16. Antimony (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.120 (.107-.135)	.053 (.045-.063)	.078 (.067-.090)	.117 (.106-.133)	.184 (.164-.208)	.272 (.236-.320)	.382 (.320-.438)	2276
Age group								
6-11 years	.188 (.151-.235)	.086 (.053-.108)	.135 (.106-.158)	.185 (.159-.208)	.250 (.200-.382)	.439 (.263-.741)	.537 (.303-1.30)	316
12-19 years	.119 (.105-.136)	.059 (.041-.073)	.083 (.070-.095)	.119 (.104-.134)	.176 (.150-.199)	.259 (.207-.310)	.310 (.231-.421)	663
20 years and older	.114 (.101-.128)	< LOD	.074 (.063-.087)	.110 (.099-.126)	.171 (.152-.202)	.257 (.229-.318)	.352 (.318-.400)	1297
Gender								
Males	.109 (.099-.121)	.052 (.041-.060)	.072 (.064-.084)	.108 (.100-.121)	.164 (.149-.178)	.224 (.209-.250)	.298 (.241-.382)	1132
Females	.132 (.115-.152)	.056 (.047-.069)	.083 (.070-.099)	.129 (.111-.148)	.210 (.182-.235)	.320 (.265-.361)	.425 (.339-.531)	1144
Race/ethnicity								
Mexican Americans	.116 (.105-.128)	.056 (.041-.071)	.082 (.074-.095)	.113 (.105-.126)	.166 (.148-.197)	.247 (.215-.280)	.327 (.280-.357)	787
Non-Hispanic blacks	.113 (.098-.131)	.053 (.045-.061)	.075 (.065-.087)	.111 (.097-.129)	.159 (.143-.184)	.236 (.195-.338)	.339 (.236-.450)	554
Non-Hispanic whites	.125 (.109-.143)	.054 (.045-.066)	.080 (.067-.095)	.121 (.106-.143)	.194 (.169-.218)	.296 (.239-.347)	.400 (.318-.476)	768

< LOD means less than the limit of detection (see previous table).

Geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, and urinary creatinine. Urinary antimony levels were slightly higher for children aged 6-11 years than for either people aged 12-19 years or 20 years and older. Urinary antimony levels in females were slightly higher than in males. It is unknown whether differences between ages or genders represent differences in exposure, body-size relationships, or metabolism.

Whether antimony at the levels reported here is a cause for health concern is not yet known; more research is needed. These urine antimony data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of antimony than those found in the general population. These data will also help scientists plan and conduct research about exposure to antimony and health effects.

Barium

CAS No. 7440-39-3

General Information

Elemental barium is a silver-white metal. In nature, it combines with other chemicals such as sulfur or carbon and oxygen. Barium compounds are used by the oil and gas industries to make drilling muds. These compounds are also produced commercially for use in paint, bricks, tiles, glass, rubber, depilatories, fireworks, and ceramics. Medically, barium sulfate is used as a contrast medium for taking X-rays of the gastrointestinal tract. Barium sulfate is insoluble and not absorbed.

People can be exposed to barium in air, water, and food. The health effects of exposure to barium compounds depend on the dose, chemical form, and water solubility. Workers employed by industries that make or use barium compounds are exposed to barium dust. Chronic accumulation of inhaled barium dust in the lung tissue may cause baritosis, a benign condition that may occur among barite ore miners. Workplace standards for external air exposure to various barium salts have been established (OSHA). Barium is considered unlikely to be carcinogenic (U.S. EPA, NTP). Information about external exposure (environmental levels) and health effects is available from the EPA IRIS Web site at http://www.epa.gov/iris and from ATSDR at http://www.atsdr.cdc.gov/toxprofiles.

Table 17. Barium

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	1.48 (1.36-1.61)	.200 (.200-.300)	.800 (.700-.900)	1.50 (1.40-1.70)	3.00 (2.80-3.30)	5.40 (4.70-6.00)	6.80 (6.20-8.40)	2180
Age group								
6-11 years	2.13 (1.77-2.56)	.800 (.600-.900)	1.20 (1.00-1.50)	2.20 (1.80-2.30)	3.90 (2.90-5.90)	6.40 (5.40-8.30)	8.30 (5.60-40.8)	297
12-19 years	1.97 (1.76-2.21)	.600 (.500-.800)	1.10 (.800-1.30)	2.00 (1.60-2.30)	3.50 (3.00-4.10)	5.90 (4.80-6.70)	9.70 (6.10-13.1)	621
20 years and older	1.35 (1.24-1.48)	.200 (.200-.300)	.700 (.500-.700)	1.40 (1.30-1.60)	2.70 (2.50-3.00)	5.00 (4.20-5.50)	6.40 (5.80-7.70)	1262
Gender								
Males	1.69 (1.50-1.89)	.300 (.200-.500)	1.00 (.800-1.10)	1.80 (1.60-2.00)	3.10 (2.80-3.40)	5.50 (4.50-6.20)	7.50 (6.20-9.40)	1083
Females	1.31 (1.19-1.45)	.300 (.200-.300)	.600 (.500-.700)	1.50 (1.20-1.60)	2.80 (2.40-3.00)	5.10 (4.20-5.80)	6.80 (5.80-10.2)	1097
Race/ethnicity								
Mexican Americans	1.34 (1.18-1.52)	.400 (.300-.400)	.600 (.500-.800)	1.30 (1.20-1.60)	2.60 (2.30-2.90)	4.50 (3.90-5.30)	6.30 (5.40-7.20)	692
Non-Hispanic blacks	1.33 (1.11-1.59)	.200 (.200-.400)	.700 (.500-.700)	1.30 (1.10-1.50)	2.50 (2.10-2.80)	5.10 (3.80-6.20)	7.40 (5.40-13.9)	540
Non-Hispanic whites	1.55 (1.40-1.72)	.300 (.300-.400)	.700 (.600-.900)	1.70 (1.60-2.00)	3.30 (3.00-3.50)	5.40 (4.60-6.20)	7.20 (6.20-9.40)	765

< LOD means less than the limit of detection, which is 0.08 µg/L.

Interpreting Urine Barium Levels Reported in the Tables

Urine barium levels were measured in a subsample of NHANES participants aged 6 years and older. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. Measuring barium at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of barium in urine does not mean that the level of barium causes an adverse health effect. Previous studies reporting urinary levels of barium in normal populations have found values roughly similar to those documented in this *Report* (Minoia et al., 1990; Paschal et al., 1998). In addition, levels determined in clinically submitted specimens are broadly similiar (Komaromy-Hiller et al., 2000). Median urinary levels of barium found in welders of barium-containing electrodes were 60 times higher than the median levels reported below (Zschiesche et al., 1992) without obvious health effects.

In the current NHANES 1999-2000 subsample, geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, and urinary creatinine. Urinary barium levels were higher for children aged 6-11 years than for either people aged 12-19 years or 20 years and older, and levels in people aged 12-19 years were higher than people aged 20 years and older. Urinary barium levels in females were higher than in males, and

Table 18. Barium (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	1.39 (1.29-1.50)	.410 (.345-.500)	.790 (.741-.863)	1.41 (1.32-1.49)	2.54 (2.25-2.80)	4.68 (4.09-5.25)	6.27 (5.47-8.09)	2180
Age group								
6-11 years	2.34 (1.86-2.95)	.651 (.502-.879)	1.41 (1.11-1.66)	2.35 (1.85-2.92)	4.46 (3.04-5.45)	8.77 (4.28-22.0)	11.4 (5.60-22.0)	297
12-19 years	1.50 (1.34-1.69)	.556 (.483-.631)	.863 (.743-1.06)	1.39 (1.26-1.60)	2.48 (2.00-3.04)	4.36 (3.26-5.33)	6.95 (4.24-11.4)	621
20 years and older	1.28 (1.19-1.38)	.374 (.298-.458)	.744 (.690-.817)	1.33 (1.22-1.42)	2.32 (2.11-2.57)	4.29 (3.69-4.84)	5.65 (5.28-6.33)	1262
Gender								
Males	1.30 (1.19-1.43)	.400 (.298-.500)	.762 (.690-.848)	1.36 (1.23-1.47)	2.39 (2.08-2.64)	4.24 (3.58-5.00)	5.61 (4.61-6.76)	1083
Females	1.48 (1.34-1.63)	.429 (.329-.526)	.846 (.741-.926)	1.46 (1.33-1.61)	2.65 (2.23-3.17)	4.86 (4.26-6.00)	7.36 (5.41-10.0)	1097
Race/ethnicity								
Mexican Americans	1.20 (1.05-1.37)	.370 (.265-.455)	.640 (.556-.744)	1.17 (.968-1.46)	2.39 (2.00-2.68)	4.00 (3.22-4.80)	5.31 (4.71-6.67)	692
Non-Hispanic blacks	.869 (.719-1.05)	.244 (.134-.316)	.469 (.361-.559)	.904 (.714-1.05)	1.64 (1.42-1.92)	3.27 (2.48-4.04)	4.84 (3.62-10.8)	540
Non-Hispanic whites	1.55 (1.40-1.72)	.500 (.367-.603)	.917 (.817-1.01)	1.55 (1.40-1.68)	2.72 (2.39-3.16)	5.00 (4.26-5.60)	6.60 (5.56-10.0)	765

< LOD means less than the limit of detection (see previous table).

levels in non-Hispanic whites were higher than in non-Hispanic blacks or Mexican Americans. It is unknown whether differences between ages, genders, or races/ethnicities represent differences in exposure, body-size relationships, or metabolism.

Whether barium at the levels reported here is a cause for health concern is not yet known; more research is needed. These urine barium data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of barium than those found in the general population. These data will also help scientists plan and conduct research about exposure to barium and health effects.

Beryllium

CAS No. 7440-41-7

General Information

Pure beryllium is a hard, gray metal. In nature, beryllium can be found in mineral rocks, coal, soil, and volcanic dust. Beryllium compounds are commercially mined, and the beryllium is purified for use in mirrors and in special metal alloys in the nuclear, electrical, aircraft, and machine-parts industries. Small amounts of beryllium dust can enter air from burning coal and oil. Exposure to beryllium occurs mostly in the workplace, near some hazardous waste sites, and from breathing tobacco smoke.

In the workplace, beryllium dust enters the body primarily through the lungs, where it remains for years, but there are little data available on how the metal accumulates in the lungs. Berylliosis, a granulomatous interstitial lung disease that results from chronic beryllium inhalation, is rarely seen today. Skin contact with beryllium may also produce dermatitis, and some people demonstrate a hypersensitivity reaction to beryllium. Workplace air standards for external exposure have been established (OSHA, ACGIH). Beryllium is an animal carcinogen, and it is reasonably anticipated to be a human lung carcinogen (IARC). NTP considers beryllium to be a known carcinogen. Information about external exposure (environmental levels) and health effects is available

Table 19. Beryllium

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	2465
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	340
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	719
20 years and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1406
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1227
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1238
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	884
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	568
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	822

< LOD means less than the limit of detection, which is 0.09 µg/L.

* Not calculated. Proportion of results below the limit of detection was too high to provide a valid result.

from the EPA IRIS Web site at http://www.epa.gov/iris and from ATSDR at http://www.atsdr.cdc.gov/toxpro-files.

Interpreting Urine Beryllium Results Reported in the Tables

Urine beryllium levels were measured in a subsample of NHANES participants aged 6 years old and older. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. Previous studies reporting urinary levels for normal populations either have reported undetectable concentrations or have not had comparable detection limits (White et al., 1998; Komaromy-Hiller et al., 2000; Minoia et al., 1990; Paschal et al., 1998). A summary of reference ranges taken from previous studies suggested that a true reference range for urinary beryllium is below many current detection limits (< 1 µg/L) (Hamilton et al., 1994). Apostoli and Schaller (2001) suggest that previous detection limits are inadequate to quantitate normal human exposure. In that study, urinary beryllium in workers correlated with air exposure measures. When air levels were below the recommended threshold limit value, urinary beryllium concentrations ranged from 0.12 to 0.15 µg/L. Because the detection limit documented in this *Report* was 0.09 µg/L and because 99.8% of values were undetectable, these NHANES 1999-2000 levels are likely to be lower than levels considered safe for workers.

Table 20. Beryllium (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	2465
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	340
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	719
20 years and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1406
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1227
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1238
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	884
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	568
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	822

< LOD means less than the limit of detection (see previous table for LOD).

* Not calculated. Proportion of results below the limit of detection was too high to provide a valid result.

Cesium

CAS No. 7440-46-2

General Information

Cesium is a silver-white metal that ignites on contact with air and reacts explosively with water. Cesium compounds can be found naturally in rock, soil, and clay. Cesium inorganic compounds are commonly used in photomultiplier tubes, vacuum tubes, scintillation counters, infrared lamps, semiconductors, high-power gas-ion devices, and as polymerization catalysts and photographic emulsions. Radioactive cesium-137 has been used medically to treat cancer.

Most human exposure to cesium occurs through diet. Little is known about the health effects of this metal. Cesium hydroxide is a corrosive and an irritant. Workplace air standards for external exposure are recommended on the basis of these irritant effects but only for certain salts (NIOSH). It is not known whether cesium compounds are carcinogenic. National agencies (ATSDR, U.S. EPA, NTP) have not reviewed exposure or health effects related to this element.

Interpreting Urine Cesium Levels Reported in the Tables

Urine cesium levels were measured in a subsample of NHANES participants aged 6 years and older. Subsamples were randomly selected within the specified age

Table 21. Cesium

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	4.35 (4.08-4.64)	1.60 (1.30-1.80)	2.90 (2.70-3.30)	4.80 (4.50-5.30)	7.10 (6.80-7.40)	9.60 (8.90-10.2)	11.4 (10.3-12.5)	2464
Age group								
6-11 years	4.87 (4.19-5.65)	2.10 (1.00-2.90)	3.80 (2.80-3.90)	5.60 (4.40-6.70)	7.30 (6.80-7.90)	9.00 (7.90-9.70)	9.70 (8.80-10.8)	340
12-19 years	4.54 (4.14-4.99)	1.80 (1.40-2.30)	3.40 (2.80-3.80)	5.10 (4.50-5.50)	6.80 (6.20-7.70)	8.80 (8.00-9.40)	10.4 (9.00-12.2)	718
20 years and older	4.26 (3.99-4.55)	1.50 (1.20-1.70)	2.80 (2.50-3.00)	4.80 (4.40-5.10)	7.10 (6.70-7.50)	9.80 (8.90-10.5)	11.6 (10.3-13.0)	1406
Gender								
Males	4.83 (4.48-5.21)	1.90 (1.70-2.40)	3.50 (3.00-3.70)	5.50 (4.90-5.80)	7.50 (7.00-8.00)	9.70 (8.90-10.3)	11.6 (10.3-13.0)	1226
Females	3.94 (3.61-4.31)	1.10 (1.00-1.30)	2.60 (2.30-2.80)	4.50 (4.00-4.80)	6.60 (6.20-7.10)	9.10 (8.20-10.0)	11.1 (9.90-12.9)	1238
Race/ethnicity								
Mexican Americans	4.31 (3.92-4.75)	1.50 (1.20-2.00)	3.00 (2.50-3.40)	4.70 (4.20-5.00)	6.60 (6.30-7.00)	9.10 (8.00-9.80)	10.9 (9.70-12.5)	884
Non-Hispanic blacks	4.93 (4.44-5.47)	2.10 (1.90-2.70)	3.70 (3.10-4.00)	5.40 (4.90-6.10)	7.40 (6.90-8.20)	9.80 (8.80-10.8)	11.5 (10.0-12.8)	568
Non-Hispanic whites	4.25 (3.91-4.62)	1.50 (1.20-1.80)	2.70 (2.40-3.00)	4.70 (4.30-5.30)	7.10 (6.70-7.70)	9.60 (8.80-10.5)	11.7 (10.3-13.1)	821

range to be a representative sample of the U.S. population. Finding a measurable amount of cesium in urine does not mean that the level of cesium causes an adverse health effect. For one small population study (Minoia et al., 1990) and one study of clinically submitted specimens (Komaromy-Hiller et al., 2000), urinary cesium levels were slightly higher than levels reported in Tables 21 and 22. Median values in this current NHANES 1999-2000 subsample are more than twice the median values reported in a non-random subsample from NHANES III (1988-1994) (Paschal et al., 1998). The cause of these differences in the aforementioned studies is not known but may be due to methodologic differences at these low levels.

In the current NHANES 1999-2000 subsample, geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, and urinary creatinine. Urinary cesium levels were higher for children aged 6-11 years than for people aged 12-19 years, with both age groups having higher levels than people aged 20 years and older. Non-Hispanic whites had higher levels than non-Hispanic blacks. It is unknown whether differences between ages, genders, or races/ethnicities represent differences in exposure, body-size relationships, or metabolism.

Whether cesium at the levels reported here is cause for health concern is not yet known; more research is

Table 22. Cesium (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	4.10 (3.89-4.31)	2.39 (2.22-2.61)	3.14 (3.04-3.26)	4.12 (3.96-4.28)	5.41 (5.21-5.71)	7.14 (6.73-7.64)	8.64 (7.78-9.76)	2464
Age group								
6-11 years	5.34 (4.94-5.77)	3.68 (3.04-3.99)	4.46 (4.17-4.69)	5.42 (5.00-6.05)	6.63 (6.09-7.18)	8.23 (6.83-9.90)	9.89 (7.57-10.7)	340
12-19 years	3.43 (3.23-3.65)	2.02 (1.87-2.22)	2.63 (2.42-2.89)	3.52 (3.24-3.73)	4.35 (4.17-4.56)	5.31 (4.85-5.99)	6.56 (5.21-10.4)	718
20 years and older	4.08 (3.86-4.31)	2.40 (2.22-2.65)	3.14 (3.01-3.27)	4.06 (3.87-4.27)	5.38 (5.07-5.71)	7.17 (6.73-7.65)	8.60 (7.77-9.76)	1406
Gender								
Males	3.78 (3.58-3.98)	2.12 (1.90-2.38)	2.97 (2.76-3.12)	3.78 (3.55-4.02)	4.96 (4.69-5.24)	6.45 (6.04-6.90)	7.71 (6.90-8.83)	1226
Females	4.43 (4.16-4.71)	2.63 (2.40-2.86)	3.36 (3.16-3.61)	4.44 (4.20-4.68)	5.92 (5.40-6.40)	7.70 (7.12-8.40)	9.38 (8.00-10.5)	1238
Race/ethnicity								
Mexican Americans	3.98 (3.71-4.27)	2.41 (2.16-2.58)	3.04 (2.86-3.23)	3.95 (3.65-4.12)	5.09 (4.66-5.44)	6.64 (6.00-7.21)	7.96 (7.20-8.95)	884
Non-Hispanic blacks	3.21 (2.88-3.56)	2.01 (1.69-2.29)	2.56 (2.27-2.77)	3.26 (3.05-3.45)	4.30 (3.99-4.55)	5.49 (5.08-5.97)	6.33 (5.90-7.08)	568
Non-Hispanic whites	4.26 (3.99-4.54)	2.54 (2.26-2.85)	3.33 (3.15-3.53)	4.28 (4.05-4.52)	5.63 (5.25-6.06)	7.27 (6.80-7.91)	8.68 (7.65-10.0)	821

needed. No relation has been established between urinary levels of cesium and health effects. These urine cesium data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of cesium than those found in the general population. These data will also help scientists plan and conduct research about exposure to cesium and health effects.

Molybdenum

CAS No. 7439-98-7

General Information

Elemental molybdenum is a silver-white, hard metal with many commercial uses, including the production of metal alloys. Compounds of molybdenum are used as corrosion inhibitors, hydrogenation catalysts, lubricants, alloys in steel, chemical reagents in hospital laboratories, and in pigments for ceramics and paints.

Molybdenum is a nutritionally essential trace element and enters the body primarily from dietary sources. Molybdenum enters the environment from the weathering of ores that contain it and from water containing the metal in its soluble forms (e.g., molybdates). In industry, dust and other fine particles produced during the refining or shaping of molybdenum are the most important sources of exposure. Workplace air standards for external exposure are generally established (OSHA, ACGIH). Generally, molybdenum has low or unknown toxicity. Some molybdenum compounds (e.g., molybdenum trioxide) may be animal carcinogens (NTP), but human carcinogenic risk is unknown (U.S. EPA). Information about external exposure (environmental levels) and health effects is available from the EPA IRIS Web site at http://www.epa.gov/iris.

Table 23. Molybdenum

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	45.9 (42.0-50.1)	12.6 (11.3-15.0)	26.7 (22.4-30.8)	50.7 (46.5-56.7)	84.9 (79.8-91.2)	134 (126-145)	178 (157-216)	2257
Age group								
6-11 years	78.2 (65.1-93.8)	31.1 (13.1-43.2)	48.9 (39.4-66.3)	83.4 (71.0-98.5)	126 (108-145)	174 (145-259)	267 (159-840)	310
12-19 years	54.3 (48.3-61.1)	16.9 (14.6-21.0)	32.6 (24.9-42.8)	60.6 (52.1-70.4)	93.3 (81.3-108)	146 (113-169)	183 (146-216)	648
20 years and older	41.7 (38.1-45.5)	11.5 (9.80-13.3)	23.3 (20.1-27.7)	46.5 (41.6-49.8)	76.7 (73.7-81.8)	125 (114-134)	167 (145-198)	1299
Gender								
Males	52.6 (47.1-58.7)	15.8 (13.2-20.1)	30.7 (25.9-34.7)	57.4 (50.1-66.2)	93.2 (83.8-106)	150 (133-175)	213 (169-252)	1121
Females	40.4 (36.4-44.7)	11.2 (8.70-12.6)	21.9 (18.1-26.9)	45.5 (40.7-50.7)	77.2 (72.7-83.8)	118 (108-132)	154 (138-175)	1136
Race/ethnicity								
Mexican Americans	47.0 (42.8-51.6)	12.8 (11.3-15.5)	29.6 (23.1-34.9)	53.2 (49.0-59.0)	80.3 (74.2-91.7)	120 (109-134)	152 (126-208)	780
Non-Hispanic blacks	57.6 (52.4-63.3)	18.6 (14.6-23.0)	34.5 (30.7-39.4)	61.8 (56.4-70.3)	97.7 (85.0-110)	151 (133-175)	202 (160-269)	546
Non-Hispanic whites	44.4 (39.2-50.4)	12.2 (9.10-15.0)	24.9 (20.0-31.1)	48.5 (42.4-56.6)	85.0 (77.2-93.9)	135 (123-152)	178 (153-221)	760

< LOD means less than the limit of detection, which is 0.6 µg/L.

Interpreting Urine Molybdenum Levels Reported in the Tables

Urine molybdenum levels were measured in a subsample of NHANES participants aged 6 years and older. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. Finding a measurable amount of molybdenum in urine does not mean that the level of molybdenum causes an adverse health effect. Because molybdenum is an essential element for good health, intake and loss in the urine is expected. One study of a small number of college students found that high molybdenum intakes were associated with high urinary levels (mean 187 ± 34 µg/24 hr) without apparent health effects (Tsongas et al., 1980). Molybdenum is conserved at low intakes, and urinary losses are greater with high intake (Turnlund et al., 1995). Copper intake can alter the absorption, excretion, and effects of molybdenum. Among infants, urinary molybdenum concentrations may be slightly lower (Sievers et al., 2001). Other factors (e.g., dietary composition) that may increase or decrease molybdenum excretion are unknown.

Levels documented in this *Report* are similar to levels found in a previous non-random subsample of the U.S. population from NHANES III (1988-1994) (Paschal et al., 1998) and roughly similar to levels in several different populations (White et al., 1998; Komaromy-Hiller et al., 2000). Also, urinary molybdenum levels of

Table 24. Molybdenum (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	43.1 (40.5-46.0)	19.4 (17.1-21.7)	28.3 (27.2-29.7)	41.5 (39.1-44.5)	63.5 (59.1-69.3)	108 (95.5-116)	144 (123-172)	2257
Age group								
6-11 years	85.8 (73.2-101)	43.1 (31.4-54.7)	60.3 (53.4-66.6)	78.9 (71.7-88.4)	122 (95.1-137)	173 (130-217)	213 (156-1040)	310
12-19 years	41.9 (38.4-45.7)	22.1 (18.6-24.5)	29.3 (26.7-33.1)	40.5 (35.9-46.2)	57.3 (50.5-65.8)	85.0 (68.4-103)	109 (83.1-185)	648
20 years and older	39.6 (37.2-42.2)	17.9 (15.5-20.7)	27.2 (25.7-28.4)	38.5 (36.5-40.7)	56.4 (53.5-60.7)	92.5 (80.7-107)	120 (112-152)	1299
Gender								
Males	40.7 (37.4-44.3)	16.9 (15.4-20.0)	26.6 (24.9-27.9)	38.5 (36.4-41.6)	62.4 (55.6-70.5)	101 (85.4-116)	131 (118-168)	1121
Females	45.5 (42.6-48.6)	22.1 (19.0-24.4)	30.7 (29.1-32.4)	43.7 (41.3-47.6)	64.4 (59.3-70.5)	111 (95.5-120)	149 (122-181)	1136
Race/ethnicity								
Mexican Americans	42.9 (40.5-45.5)	20.4 (16.4-23.9)	30.8 (28.1-32.8)	43.2 (40.9-45.6)	61.6 (57.0-66.2)	89.0 (80.2-102)	115 (97.8-132)	780
Non-Hispanic blacks	37.2 (34.3-40.3)	16.7 (14.5-20.3)	25.2 (23.5-26.8)	37.0 (34.2-40.6)	55.9 (51.6-62.4)	88.2 (73.3-109)	117 (88.4-141)	546
Non-Hispanic whites	44.4 (40.7-48.5)	19.6 (16.7-23.3)	28.8 (27.1-31.1)	42.1 (38.8-47.0)	65.3 (57.6-72.7)	116 (101-126)	172 (131-191)	760

< LOD means less than the limit of detection (see previous table).

adults in two smaller studies (Iversen et al., 1998; Allain et al., 1991) generally corresponded to the concentrations in this *Report*. In the current NHANES 1999-2000 subsample, geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, and urinary creatinine. Urinary molybdenum levels were higher for 6-11 year olds than for people aged 12-19 years, with both age groups having higher levels than people in the 20 years and older group. Non-Hispanic blacks had slightly lower levels than non-Hispanic whites. It is unknown whether differences between ages or races/ethnicities represent differences in exposure, body-size relationships, or metabolism.

These urine molybdenum data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of molybdenum than those found in the general population. These data will also help scientists plan and conduct research about molybdenum exposure and health effects.

Platinum

CAS No. 7440-06-4

General Information

Platinum is a silver-gray, lustrous metal found naturally in extremely low amounts in the earth's crust and typically is associated with sulfide-ore bodies of nickel, copper, and iron. Important properties of platinum are resistance to corrosion, strength at high temperatures, and high catalytic activity. Platinum-rhodium compounds are used in glass and glass-fiber manufacture and in high-temperature thermocouples. Platinum compounds are also used in electrodes and jewelry, as oxidation catalysts in chemical manufacturing, and in thick-film circuits printed on ceramic substrates. Platinum-rhodium and platinum-palladium crystals are used as catalysts in petroleum refining and to control automobile-exhaust emissions.

Higher environmental soil concentrations of platinum have been associated with nearby roadways (Farago et al., 1998). Workplace air standards for external exposure are generally established for soluble salts (OSHA, ACGIH) or recommended for the metal form (NIOSH). The pharmaceutical, cisplatin, is an animal carcinogen (NTP) and a possible human carcinogen. The carcinogenicity of other platinum compounds is unknown. Information about external exposure (environmental levels) and health effects is available (NRC/NAS, 1977).

Table 25. Platinum

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	2465
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	340
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	719
20 years and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1406
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1227
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1238
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	884
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	568
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	822

< LOD means less than the limit of detection, which is 0.03 µg/L.

* Not calculated. Proportion of results below the limit of detection was too high to provide a valid result.

Interpreting Urine Platinum Levels Reported in the Tables

Urine platinum levels were measured in a subsample of NHANES participants aged 6 years and older. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. In the current NHANES 1999-2000 subsample, urinary platinum levels were not detectable in 98.8% of the sample (detection limit was 0.03 µg/L). Previous studies reporting measurements in normal populations have found detectable and higher values than those reported in Table 25 (Vaughan et al., 1992; Paschal et al., 1998) and are possibly due to methodologic differences, although population differences may exist. Platinum-industry and precious-metal workers can have urinary concentrations 1,000 times higher than unexposed populations (Schierl et al., 1998). Gold-platinum alloys used for dental fillings also may contribute to urinary platinum concentrations (Schierl et al., 2001).

Table 26. Platinum (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval) 10th	25th	50th	75th	90th	95th	Sample size
Total, age 6 and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	2465
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	340
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	719
20 years and older	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1406
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1227
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1238
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	884
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	568
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	822

< LOD means less than the limit of detection (see previous table for LOD).

* Not calculated. Proportion of results below the limit of detection was too high to provide a valid result.

Thallium

CAS No. 7440-28-0

General Information

Elemental thallium is a blue-white metal found in small amounts in soil and in sulfide-based minerals. In the past, thallium was obtained as a byproduct of the smelting of other metals; however, it has not been produced in the United States since 1984. It is still used in small amounts in the electronics industry.

Thallium exposure occurs primarily from commercial processes such as coal-burning and smelting. In these and other sources, thallium is produced in fine particles that can be absorbed by inhalation. Thallium is toxic in small amounts and may cause peripheral neuropathy and alopecia following chronic exposures. Intentional or accidental overdoses result in multiorgan failure, neurologic injury, and death. Accidental ingestion of thallium can occur by eating rat poison that contains water-soluble thallium salts. In the United States, thallium has been banned for use in rat poisons. Other abandoned uses have included thallium as a component of cosmetic depilatories and antifungal agents.

Workplace air standards for external exposure are generally established (OSHA, ACGIH). Chronic high-level exposures can cause gastrointestinal and neurologic symptoms. Evidence for the carcinogenicity of thallium

Table 27. Thallium

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.176 (.167-.186)	.060 (.060-.070)	.110 (.110-.130)	.200 (.180-.200)	.280 (.270-.300)	.400 (.380-.420)	.450 (.420-.470)	2413
Age group								
6-11 years	.201 (.177-.228)	.090 (.060-.110)	.150 (.110-.160)	.200 (.160-.250)	.300 (.260-.340)	.410 (.340-.430)	.440 (.390-.500)	336
12-19 years	.202 (.186-.219)	.090 (.070-.100)	.150 (.120-.170)	.210 (.200-.240)	.290 (.270-.330)	.410 (.370-.450)	.460 (.420-.510)	697
20 years and older	.170 (.161-.179)	.050 (.050-.060)	.100 (.090-.110)	.180 (.180-.200)	.290 (.260-.300)	.400 (.380-.420)	.450 (.420-.470)	1380
Gender								
Males	.197 (.184-.211)	.070 (.060-.080)	.140 (.130-.150)	.220 (.200-.230)	.310 (.290-.340)	.390 (.380-.420)	.440 (.420-.480)	1200
Females	.159 (.147-.173)	.060 (.050-.060)	.100 (.080-.110)	.180 (.150-.200)	.270 (.250-.290)	.380 (.350-.410)	.450 (.420-.480)	1213
Race/ethnicity								
Mexican Americans	.172 (.157-.188)	.060 (.050-.080)	.110 (.090-.130)	.190 (.170-.210)	.260 (.250-.290)	.370 (.330-.410)	.450 (.390-.480)	861
Non-Hispanic blacks	.217 (.200-.236)	.100 (.070-.110)	.140 (.130-.160)	.220 (.210-.240)	.340 (.310-.370)	.440 (.400-.480)	.550 (.460-.610)	561
Non-Hispanic whites	.170 (.158-.182)	.060 (.050-.060)	.110 (.090-.120)	.200 (.180-.210)	.280 (.260-.310)	.400 (.370-.420)	.440 (.420-.480)	801

is inadequate or unknown (IARC, NTP, U.S. EPA). Information about external exposure (environmental levels) and health effects is available from ATSDR at http://www.atsdr.cdc.gov/toxprofiles and from the EPA IRIS Web site at http://www.epa.gov/iris.

Interpreting Urine Thallium Levels Reported in the Tables

Urine thallium levels were measured in a subsample of NHANES participants aged 6 years and older. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. Finding low amounts of thallium in urine does not mean that the level of thallium causes adverse health effects. Urinary concentrations of 100 µg/L in asymptomatic workers (500 times higher than observed in this NHANES sample) are thought to correspond to workplace exposures at the threshold limit value of 0.1 mg/m^3 (Marcus, 1985). Brockhaus et al. (1981) studied 1,265 people living near a thallium-emitting cement plant in Germany. Nearby residents were exposed by eating garden plants on which thallium had been deposited. Seventy-eight percent of the urine specimens in that study contained > 1 µg/L, with concentrations ranging up to 76.5 µg/L. There was no increase in the prevalence of symptoms at levels < 20 µg/L and only a slight increase in neuroasthenic-type symptoms above 20 µg/L.

Previous studies have suggested that normal amounts of

Table 28. Thallium (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.166 (.158-.174)	.090 (.085-.098)	.125 (.117-.130)	.168 (.162-.175)	.224 (.214-.236)	.297 (.273-.319)	.366 (.333-.389)	2413
Age group								
6-11 years	.221 (.200-.244)	.130 (.113-.145)	.169 (.147-.188)	.221 (.196-.233)	.292 (.246-.341)	.375 (.318-.444)	.424 (.356-.600)	336
12-19 years	.153 (.144-.161)	.088 (.081-.098)	.117 (.108-.127)	.154 (.146-.163)	.205 (.184-.223)	.257 (.229-.285)	.321 (.258-.375)	697
20 years and older	.162 (.153-.171)	.089 (.083-.097)	.121 (.114-.130)	.167 (.157-.173)	.217 (.205-.232)	.285 (.265-.313)	.364 (.313-.400)	1380
Gender								
Males	.154 (.147-.161)	.085 (.076-.090)	.118 (.112-.126)	.156 (.149-.164)	.202 (.192-.214)	.269 (.254-.297)	.338 (.300-.364)	1200
Females	.178 (.166-.191)	.099 (.089-.107)	.131 (.119-.147)	.182 (.169-.196)	.244 (.227-.258)	.313 (.286-.364)	.380 (.364-.421)	1213
Race/ethnicity								
Mexican Americans	.158 (.148-.169)	.087 (.077-.097)	.118 (.103-.129)	.159 (.148-.175)	.212 (.200-.234)	.282 (.265-.305)	.338 (.306-.389)	861
Non-Hispanic blacks	.142 (.134-.151)	.076 (.064-.085)	.102 (.096-.109)	.140 (.131-.150)	.200 (.179-.214)	.277 (.242-.312)	.383 (.303-.431)	561
Non-Hispanic whites	.169 (.158-.181)	.093 (.085-.104)	.129 (.117-.142)	.173 (.167-.183)	.226 (.213-.243)	.300 (.269-.329)	.364 (.331-.385)	801

thallium in the urine should be < 1 µg/L (Schaller et al., 1980; Brockhaus et al., 1981; Minoia et al., 1990), which are consistent with levels documented in this NHANES 1999-2000 subsample. Other population surveys have demonstrated urinary levels of roughly similar magnitude (White et al., 1998; Minoia et al., 1990; Paschal et al., 1998). The variation of urinary thallium levels across this NHANES 1999-2000 subsample was narrow, possibly indicating limited opportunities for exposure. Geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, and urinary creatinine. Urinary thallium levels were slightly higher for people aged 6-11 years than for the other two age groups. Levels in Mexican Americans were slightly lower than in non-Hispanic whites. It is unknown whether differences between ages or races/ethnicities represent differences in exposure, body-size relationships, or metabolism.

Whether thallium at the levels reported here is a cause for health concern is not yet known; more research is needed. These urine thallium data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of thallium than those found in the general population. These data will also help scientists plan and conduct research about thallium exposure and health effects.

Tungsten

CAS No. 7440-33-7

General Information

Tungsten is a steel-gray to tin-white metal naturally occurring in the earth's crust, mainly as scheelite ($CaWO_4$). A major use of tungsten is in the production of hard metals, such as tungsten carbide, which is used in rock drills and metal-cutting tools, or ferrotungsten, which is used in the steel industry. Additionally, tungsten compounds are used as catalysts in the petroleum industry, lubricating agents, filaments for incandescent lamps, and bronzes in pigments.

Most background environmental exposures to tungsten are from the soluble forms, such as tungstate salts, whereas occupational exposure is from tungsten metal dusts released during the grinding or drilling of metals. Workplace air standards for external exposure are generally established (ACGIH) or recommended (NIOSH). Evidence for the carcinogenicity of tungsten is inadequate or unknown (IARC, NTP).

Interpreting Urine Tungsten Levels Reported in the Tables

Urine tungsten levels were measured in a subsample of NHANES participants aged 6 years and older. Subsamples were randomly selected within the specified age

Table 29. Tungsten

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.085 (.077-.093)	< LOD	< LOD	.090 (.080-.090)	.180 (.150-.200)	.320 (.270-.370)	.500 (.410-.550)	2338
Age group								
6-11 years	.153 (.122-.192)	< LOD	.080 (.060-.120)	.160 (.120-.190)	.260 (.210-.330)	.490 (.360-.590)	.590 (.510-.950)	320
12-19 years	.106 (.090-.125)	< LOD	.050 (<LOD-.060)	.110 (.080-.120)	.200 (.170-.240)	.360 (.300-.440)	.530 (.410-.780)	679
20 years and older	.076 (.069-.083)	< LOD	< LOD	.070 (.070-.080)	.150 (.130-.190)	.270 (.250-.320)	.440 (.360-.520)	1339
Gender								
Males	.099 (.085-.114)	< LOD	.050 (<LOD-.060)	.100 (.080-.110)	.210 (.170-.240)	.380 (.310-.480)	.530 (.440-.780)	1160
Females	.073 (.067-.079)	< LOD	< LOD	.070 (.060-.070)	.140 (.120-.170)	.270 (.240-.290)	.390 (.320-.470)	1178
Race/ethnicity								
Mexican Americans	.105 (.090-.124)	< LOD	.060 (.040-.070)	.100 (.090-.120)	.190 (.160-.240)	.390 (.300-.500)	.550 (.430-.810)	790
Non-Hispanic blacks	.106 (.091-.123)	< LOD	.040 (<LOD-.050)	.090 (.080-.110)	.200 (.170-.240)	.360 (.280-.490)	.550 (.400-.810)	562
Non-Hispanic whites	.083 (.075-.093)	< LOD	< LOD	.070 (.060-.090)	.170 (.150-.200)	.310 (.270-.380)	.460 (.380-.550)	802

< LOD means less than the limit of detection, which is 0.03 µg/L.

range to be a representative sample of the U.S. population. Measuring tungsten at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of tungsten in urine does not mean that the level of tungsten causes an adverse health effect. A non-random subsample from NHANES III found higher values than those reported in Table 29 (Paschal et al., 1998), possibly due to methodologic differences. One small study of unexposed individuals (n = 14) yielded values similar to those reported here (Schramel et al., 1997). During grinding operations that release tungsten metal into the air, workers had elevated urinary tungsten levels that were more than 900 times higher than the overall geometric mean in the NHANES 1999-2000 subsample (Kraus et al., 2001). In addition, these urinary levels in workers did not correlate with air-exposure levels. Kraus et al. (2001) also indicated a reference value for unexposed populations of 1 µg/gram of creatinine (or 0.86 µg/L) as the 95th percentile. The application of the technique of neutron activation analysis to a control group of non-metal workers showed mean urine tungsten levels similar to levels at the 95th percentile of the NHANES 1999-2000 subsample, whereas the tungsten-worker group had mean urine levels 35 times higher (Nicolaou et al., 1987). The variation of urinary tungsten levels across this NHANES subsample was narrow, possibly indicating limited opportunities for exposure. Geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, and urinary

Table 30. Tungsten (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.079 (.072-.087)	< LOD	< LOD	.075 (.069-.082)	.136 (.119-.156)	.245 (.203-.301)	.381 (.314-.426)	2338
Age group								
6-11 years	.168 (.144-.196)	< LOD	.099 (.087-.116)	.169 (.141-.198)	.275 (.216-.326)	.438 (.326-.667)	.614 (.452-.880)	320
12-19 years	.079 (.070-.089)	< LOD	.045 (.038-.055)	.076 (.069-.084)	.137 (.117-.155)	.226 (.173-.262)	.339 (.234-.479)	679
20 years and older	.072 (.065-.080)	< LOD	< LOD	.069 (.062-.075)	.117 (.104-.136)	.203 (.174-.276)	.339 (.245-.421)	1339
Gender								
Males	.077 (.067-.087)	< LOD	.041 (.036-.045)	.071 (.060-.082)	.141 (.119-.165)	.271 (.200-.383)	.439 (.342-.573)	1160
Females	.082 (.075-.088)	< LOD	< LOD	.079 (.074-.084)	.133 (.116-.150)	.235 (.200-.274)	.339 (.278-.383)	1178
Race/ethnicity								
Mexican Americans	.099 (.084-.116)	< LOD	.055 (.043-.064)	.096 (.080-.109)	.178 (.146-.208)	.316 (.256-.412)	.493 (.354-.727)	790
Non-Hispanic blacks	.069 (.061-.077)	< LOD	.036 (.030-.047)	.069 (.061-.080)	.121 (.109-.144)	.201 (.185-.231)	.360 (.217-.465)	562
Non-Hispanic whites	.083 (.074-.093)	< LOD	< LOD	.077 (.069-.087)	.139 (.119-.169)	.271 (.206-.339)	.383 (.314-.438)	802

< LOD means less than the limit of detection (see previous table for LOD).

creatinine. Urinary tungsten levels were higher for people aged 6-11 years than for the other two age groups. Levels in Mexican Americans were higher than in non-Hispanic blacks. It is unknown whether differences between ages or races/ethnicities represent differences in exposure, body-size relationships, or metabolism.

Whether tungsten at the levels reported here is a cause for health concern is not yet known; more research is needed. These urine tungsten data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of tungsten than levels found in the general population. These data will also help scientists plan and conduct research about tungsten exposure and health effects.